

Remarks

Claims 34-54 are pending in this application. Applicant will address the issues raised with regard to these claims and the application in the order present in the Office Action. Amendments are submitted with both 'clean' and 'highlighted' pages.

Priority

Applicant has amended page 1 of the Specification to include a specific reference to the prior application.

Specification

To resolve the objection to the Title, applicant has amended the title to clarify that the claimed invention is directed to a spacer for centrifugal impellers.

With regard to the objection that the Patent Application Serial Number 09/204,867 is no longer co-pending, applicant has amended this reference to identify that this application is now U.S. Patent 6,290,467 B1 as issued on 18 September 2001.

With regard to the objections raised to applicant's Registered Trademark CenTraVac®, applicant has capitalized that trademark as requested by the Examiner. The further requirement that it be accompanied by the "generic terminology" has already been complied with in the original language since the trademark is identified as (a) a registered trademark (beginning of line 18 on page 9) and has been identified as applicable to centrifugal compressors (see line 17 of page 9). Applicant is unclear as to what further requirement that the Examiner is requiring and ask that the Examiner provide an example of such requirement if the Examiner maintains this objection.

Drawings

Applicant traverses the objection under 37 C.F.R. Section 1.84(p)(4) relative to "reference character '200'" on the basis that the objection is groundless and incorrect. 37 C.F.R. Section 1.84(p)(4) states that "the same part of an invention appearing in more than one

view of the drawing must always be designated by the same reference character and the same reference character must never be used to designate different parts". Reference numeral 200 is designated throughout the Specification as a contoured spacer body. For example see the brief description of the several views of the drawings on page 7 with reference to Figure 3, 4, 5, 6, 7, 8 and the related description thereof in the patent application. These Figures show various embodiments of the countered spacer body but all are the countered spacer body of the Specification. Applicant has appropriately used different reference numerals for the differing features shown in the various embodiments of the contoured spacer body 200 as exemplified in these figures. The Examiner's requirement that the spacer body 200 be redesignated to a different reference numeral for Figure 6 is contrary to the cited section of 37 C.F.R. and should be withdrawn.

With regard to the Drawing Objection to the spacer body being improperly labeled as item 232 in Figure 5, corrected drawings are submitted herewith so that the lead line for 232 identifies the spring and not the spacer body.

#### Claim Objections

The grammatical correction required by the Examiner in claim 43 has been made.

#### Claim Rejections 35 U.S.C. Section 112

With regard to the rejections of claims 47 and 48 with regard to the recitation of truncated end on a spacer body, these claims have been rewritten to specify that the truncated end is associated with the impeller as is described in the Specification on page 10, line 5 and on page 15, line 9, for example.

The Examiner has rejected claims 34-54 under 35 U.S.C. Section 112, second paragraph, on the basis that the adjectives "spring" as used in line 6 of claim 35 is indefinite because the claims lack recitation of a spring. While applicant does not believe that the Examiner's rejection is proper with regard to requiring an adjective in a claim to also be used as a noun, applicant has appropriately amended

the preamble and has added a dependent claim relative to the spring. Similar amendments have been made to claim 42, 43 and 51. This is believed to resolve the rejection under 35 U.S.C. Section 112, second paragraph, to claims 34-54 in general.

Applicant traverses the rejection of claim 42 with regard to the Examiner's rewriting of "washer contact surface" to "contact surface" inasmuch as a protective washer is a claim element in dependent claim 48.

With regard to the rejection of claim 45 with regard to the word "recess", applicant has amended claims 43, 45 and 46 to specify first and second recesses.

With regard to the rejection of claim 47 relative to the terminology "the front face", claims 46 and 45 have been amended to clarify a fastener front face and an impeller front face.

With regard to the rejection of claim 48, the antecedent basis of spacer assembly has been corrected and claims 45 through 49 have been amended to correct the preamble to agree with claims 42-44.

With regard to the rejection of claim 51 with regard to the rear surface, applicant has deleted this language.

#### Claim Rejections 35 U.S.C. Section 102

Applicant traverses the rejection of claims 34-53 under 35 U.S.C. Section 102(b) in view of Zoehfeld. The surface 58 in Zoehfeld is not recessed and is described in Zoehfeld as a relatively diverging, conical camming surface formed on the back end of the impeller hub. Applicant submits that a sloped surface is not a recess.

Each claim on file has further been amended to specify that the abutment is cylindrical in nature. Zoehfeld does not and cannot meet this requirement and each claim on file is submitted to be novel in view of Zoehfeld for this reason.

Claim Rejections Under 35 U.S.C. Section 103

The claims on file are submitted to be novel and patentable in view of Zoehfeld. Zoehfeld stresses the unreliability of conventional lock washers (see Zoehfeld, column 1, lines 32-34) and teaches away from the use of such washers. The arrangement claimed in the claims on file relative to cylindrical spring spacing abutments allows the use of Belleville washers in an easy and reliable manner. A person of ordinary skill would recognize the teaching away of Zoehfeld and would not consider Zoehfeld to be particularly relevant due to this teaching away. Furthermore, Zoehfeld makes no suggestions regarding any modifications which might result in the claimed invention. Consequently, applicant submits that the claims on file are novel and patentable over the prior art of record whether taken individually or in combination.

With the foregoing amendments and remarks, the issues raised in the Office Action are believed to be fully addressed and the application in condition for immediate allowance.

Respectfully Submitted,



William O'Driscoll  
Registration No. 33,294

Telephone Number: (608) 787-2538

PATENT

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D E S C R I P T I O N

## TITLE OF THE INVENTION

[CENTRIFUGAL IMPELLER ASSEMBLY]  
SPACER FOR CENTRIFUGAL IMPELLER

## INVENTORS

RANDY E. DEWHIRST

MARK W. HARRISON

Related Applications

This is a divisional application of U.S. Patent Application Serial No. 09/454,938 filed December 3, 1999, now U.S. Patent 6,290,467 B1 issued on 18 September 2001.

## BACKGROUND OF THE INVENTION

This invention relates to centrifugal gas compressors and, more particularly, to an impeller and shaft assembly used in a high-speed gas compressor in a refrigeration plant or other chiller.

Centrifugal gas compressors have one or more impellers rotated in a cavity for compressing a gas, such as refrigerant vapor. The one or more impellers are mounted on a pinion shaft that is turned by a motor. In centrifugal gas compressors, it is important that the impellers and pinion shaft mounting arrangements are simple and efficient to manufacture, install and operate. In particular, overly complex attachment arrangements involving the machining of complementary grooves and threads in male and female parts pose a greater burden on highly skilled machinists, a resource that is both finite and costly. More particularly, such arrangements are more likely to be damaged during transport, installation and normal running of the compressor.

U.S. Patent No. 4,257,744 describes an impeller and shaft assembly that includes a cap screw, a Belleville washer or spring, a deformable socket machined into the rear of an

Now refer to Figures 2 and 3, and specifically to the interior of a centrifugal compressor 12. The compressor 12 includes an impeller assembly including impellers 40, 50 mounted on a rotatable shaft 64. The compressor 12 has a gas inlet 30, a gas outlet 32, and internal passages 34 directing refrigerant gas from the inlet 30, into and through the first stage impeller 40, the second stage impeller 50, and to the outlet 32. The rear end 264 of a fastener 62 such as a bolt (or other device allowing radial rotation while providing axial clamping force) is connected to the rotatable shaft 64 to removably attach the impeller 40 to the rotatable shaft 64. Although the preferred embodiment of this invention is shown as a gear drive centrifugal compressor, the impeller assembly is generally applicable to all centrifugal compressors as well as to other compressors having an impeller 40 mounted on a terminal end 66 of a rotatable shaft such as rotatable shaft 64. Exemplary centrifugal compressors are sold under the registered trademark CENTRAVAC [CenTraVac] by The Trane Company, a Division of American Standard Inc. having a principal place of business in La Crosse, Wisconsin. Exemplary centrifugal compressors are shown in commonly assigned U.S. Patents 3,805,547 to Eber and 3,853,433 to Roberts et al., both of which are incorporated by reference herein.

Referring to FIGS.2 and 3, a first stage impeller and shaft assembly 90 including the first stage impeller 40 depicting an aspect of this invention is disclosed. The impeller 40 has an axial bore 100 through it, a front face 102 intersecting with the axial bore 100, and a rear face 104 that is adapted to fit the driving end 66 of the rotatable shaft 64. Figure 3 does not show the details of the connection between the impeller 40 and the shaft 64, which can be conventional.

For two examples, either a conventional splined joint or the three-lobed connection described in co-pending U.S. Serial No. 09/204,867, filed by the present assignee on December 3, 1998 now U.S. Patent 6,068,457 B1 issued May 30, 2000, can be used.

The front face 102 of the impeller 40 is truncated at an end 105 and optionally has a recess 110 to accommodate a contoured spacer body 200, a protective washer 120 and an expanson such as a spacer assembly 150. For purposes of this application, a contoured spacer body is a device having an external surface which is aerodynamically contoured and having an internal portion acting as a spacer. The spacer assembly 150 provides a known resistance when compressed.

The protective washer 120, preferably a hardened steel washer, has a front face 122 and a rear face 124. The rear face 124 is seated against the front face 102 (the recess 110 if present) of the impeller 40. The protective washer 120 has an aperture 126 registered with the axial bore 100.

Referring to Figures 3 and 4, the contoured spacer body 200 includes a front surface 202 and a rear surface 204. The contoured spacer body 200 is symmetrical about an axis 206, and the front surface 202 includes a contoured surface 210 at an angle or a curve relative to the axis 206. The rear surface 204 includes a spring spacing abutment 220 including a washer contact surface 222 at the end of the abutment 220. The spring spacing abutment 220 is axially dimensioned relative to the axis 206 so that the spacer assembly 150 deflects at a desired amount. The contoured spacer body 200 includes a center portion 224 having a rear recess 226 arranged in the rear surface 204 about the spring spacing abutment 220. A central bore 230 runs through the center portion 224 symmetrical about the axis 206. The washer contact surface 222 engages the protective washer 120. The recess 226 provides a spring

34. (once amended) A spacer body for engaging a tension providing device such as a spring comprising:

a front face having an aerodynamic contour symmetrically arranged about an axis;

a rear face axially spaced from the front face;

a recessed spring bearing surface in the rear face for receiving the tension providing device;

a cylindrical spring spacing abutment projecting in an axial direction from the bearing surface and having an axial dimension controlling the deflection of the tension providing device; and

a central bore.

42. (once amended) A spacer for attachment to an impeller in conjunction with a spacer assembly having tension providing device as a spring comprising:

a contoured spacer body symmetrical about an axis and including a front surface and a rear surface;

the front surface including a contoured surface at an angle or curve relative to the axis;

the rear surface including a cylindrical spring spacing abutment including a washer contact surface at an end of the abutment wherein the spring spacing abutment is axially dimensioned relative to the axis so that a spacer assembly [contacting] used in conjunction with the abutment deflects at a desired amount.

43. (once amended) The spacer of claim 42 wherein the contoured spacer body further includes a center portion [have] having a first recess arranged in the rear surface about the spring spacing abutment.

45. (once amended) The spacer [body] of claim 44 wherein the front surface includes a second recess and a forward facing shoulder in the second recess.

46. (once amended) The spacer [body] of claim 45 further including a fastener located in the second recess and having a fastener front face wherein the second recess is sized to ensure that the fastener front face is seated flush across the central bore in order to make a substantially continuous surface.

47. (once amended) The spacer [body] of claim 44 wherein the impeller includes an impeller front face further including a truncated end in the impeller front face.

48. (once amended) The spacer [body] of claim 47 wherein the truncated end is sized to accommodate a protective washer, [a] the spacer assembly, and the contoured spacer body.

49. (once amended) The spacer [body] of claim 45 wherein the body has an aerodynamic portion extending slightly around the spring spacing abutment.

51. (once amended) A spacer for engaging a tension providing device such as a spring comprising:

a contoured spacer body including a domed front end [and a rear surface] where the spacer body is symmetrical about an axis; the domed front end including a front face, a rear face, a cylindrical spring spacing abutment having an axial dimension sized to deflect the tension providing device a desired amount, and a recess spring bearing surface in the rear face for receiving the tension providing device.

52. (once amended) The spacer of claim 51 wherein the front face includes a recess and the rear face includes a fastener projecting in an axial direction.